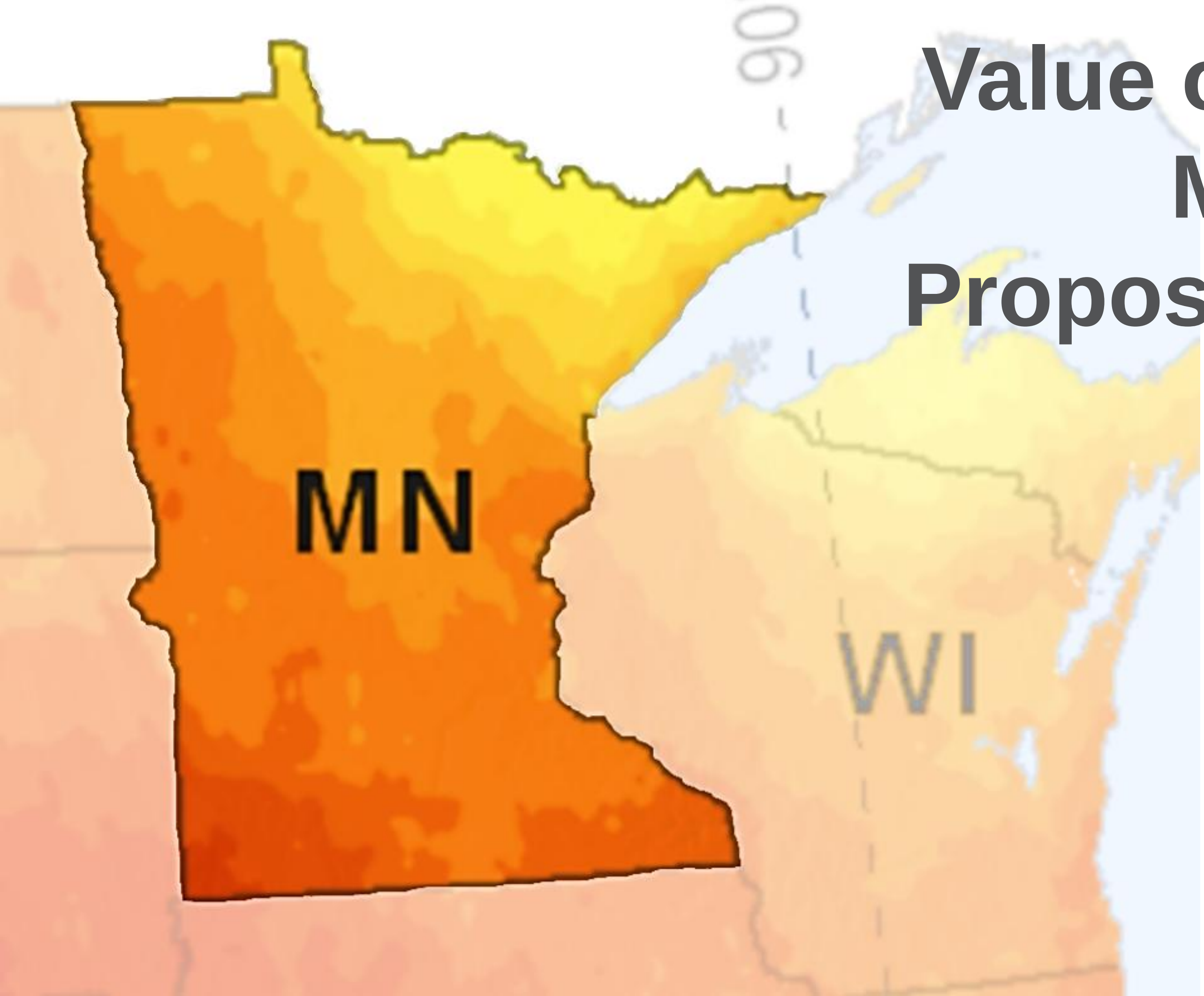

Value of Solar Tariff Methodology: Proposed Approach

October 1, 2013

Prepared for
Minnesota Department of Commerce, Energy Division

Prepared by
Clean Power Research

Agenda

- Background
- Framework
- VOS Components
- Fleet Production Shape
- Loss Savings
- Economic Methods

Agenda

- **Background**
- Framework
- VOS Components
- Fleet Production Shape
- Loss Savings
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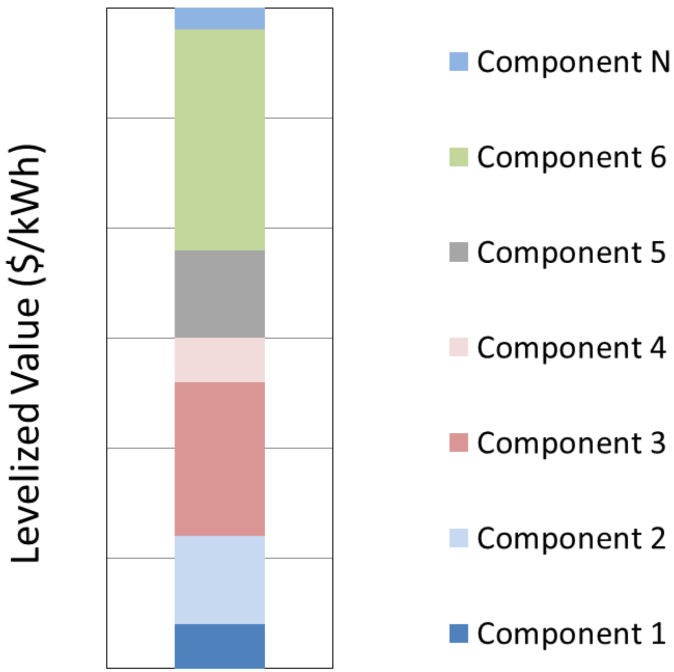
Legislation and Project Background

- Minnesota passed legislation* in 2013 that allows IOUs to apply to the PUC for a Value of Solar (VOS) tariff as an alternative to net metering.
- The methodology must meet certain requirements contained in the legislation.
- Commerce must submit the VOS methodology to the PUC by January 31, 2014. This methodology must be used by the IOUs who apply for the VOS tariffs.
- Commerce selected Clean Power Research to support them in the process of developing the methodology.

* MN Laws 2013, Chapter 85 HF 729, Article 9, Section 10

VOS Methodology Overview

- The VOS methodology will specify which components are to be included, and how they will be calculated.
- Inputs will include utility costs, economic assumptions, utility loads, and may include other external costs and assumptions.



VOS Calculation Format

	Economic Value ($/kWh)	X	Load Match (No Losses) (%)	X	Distributed Loss Savings (%)	=	Distributed PV Value ($/kWh)
Component 1	E1		M1		S1		D1
Component 2	E2		M2		S2		D2
Component 3	E3		M3		S3		D3
…							
							D4
Component N	EN		MN		SN		DN
							Value of Solar

The VOS methodology will include

- methodology to determine hourly PV fleet production shape
- methodology to perform an economic analysis
- methodology for load match analysis (hourly PV/load correlation)
- methodology for marginal loss savings analysis

VOS Methodology: Statutory Requirements

- VOS is to include value to utility, its customers, and society.
- VOS **must** include: energy, delivery, generation capacity, transmission capacity, transmission and distribution line losses, and environmental value.
- VOS **may** include: other values into the methodology, including credit for locally manufactured or assembled energy systems, systems installed at high-value locations on the distribution grid, or other factors. If included, these must be tied to utility costs/benefits.
- VOS represents present value of future value streams. It will be recalculated annually. Contract term must be at least 20 years, same credit per kWh over term.
- Implemented as a VOST credit (not a payment)

Not Directly Included in VOS Methodology

The legislation includes implementation requirements that will not be addressed in the report:

- Systems must be operated primarily for customer energy needs (size limits)
- Interconnection dates
- Rate-setting for consumption and standby charges
- Credit amount must not be lower than the utility's applicable retail rate for the first three years.
- Monthly credit carryovers and annual true-up
- Interconnection requirements
- Metering equipment

VOS Methodology Objectives

- Accurately account for all relevant value streams.
- Simplify input data set, where possible.
- Simplify methodology, where warranted.
- Easy to modify, if necessary, in future years.
- Provide transparency
  - Will define a "VOS Intermediate Data Standard" explicitly identifying all key input assumptions. (e.g., solar-weighted heat rate, distribution cost escalation rate, cost of capacity). This will provide all stakeholders with comparable data across utilities and other studies outside Minnesota.
  - With the same intermediate dataset, all stakeholders will be able to derive the same levelized $/kWh value.
  - Will include an example calculation showing annual savings calculation details. This will be used to further ensure that users of the methodology are performing calculations correctly.

VOS Intermediate Data Standard

The methodology will include a required data format similar to this

	Example Input	Units	Input Value:
PV Assumptions			
PV degradation rate	0.50%	per year	
PV system life	25	years	
Economic Factors			
Discount rate	6.00%	per year	
General escalation rate	2.50%	per year	
Generation Factors			
Gen capacity cost (installed)	$1,000	per kW	
Years until new capacity is needed	5	years	
Heat rate (first year)	7050	BTU/kWh	
Plant degradation	0.10%	per year	
O&M cost (first Yyear) - Fixed	$10.00	$ per kW-year	
O&M cost (first Yyear) - Variable	$2.00	$ per MWh	
O&M cost escalation rate	2.50%	per year	
Reserve planning margin	15.0%	%	
NG Wholesale Market Factors			
End of term nat gas futures escalation	3.00%	per year	
Fuel price overhead (annual average)	10.00%	%	

EXAMPLE

■ ■ ■

Example VOS Calculation

The methodology will include a complete example calculation

		Economic Factors and PV Production							Fuel Value					
Year	Analysis Year	Utility Discount Factor	Risk-Free Discount Factor		Within PV Service Life?	PV Production (kWh)	Discounted PV Production (kWh)		Fuel Price ($/MMBtu)	Burnertip Fuel Price ($/MMBtu)	Heat Rate (Btu/kWh)	UOG Fuel Cost ($/kWh)	Fuel Savings ($)	Disc. Fuel Savings ($)
2014	0	1.000	1.000		1	16,053,576	16,053,576		$3.98	$3.98	8024	$0.032	$512,079	$512,079
2015	1	0.909	0.999		1	15,973,308	14,521,189		$3.82	$3.82	8024	$0.031	$489,604	$445,095
2016	2	0.826	0.994		1	15,893,442	13,135,076		$4.13	$4.13	8024	$0.033	$526,493	$435,118
2017	3	0.751	0.986		1	15,813,974	11,881,273		$4.53	$4.53	8024	$0.036	$574,912	$431,940
2018	4	0.683	0.971		1	15,734,904	10,747,151		$5.09	$5.09	8024	$0.041	$642,928	$439,129
2019	5	0.621	0.951		1	15,656,230	9,721,287		$5.66	$5.66	8024	$0.045	$711,200	$441,599
2020	6	0.564	0.927		1	15,577,949	8,793,346		$5.96	$5.96	8024	$0.048	$744,874	$420,462
2021	7	0.513	0.899		1	15,500,059	7,953,981		$5.85	$5.85	8024	$0.047	$728,[illegible]71	$[illegible]73,667
2022	8	0.467	0.872		1	15,422,559	7,194,737		$6.17	[illegible]	8024	$0.049	$763,[illegible]10	$355,950
2023	9	0.424	0.842		1	15,345,446	6,507,967		$7.02	$7.02	8024	$0.056	$864,[illegible]69	$366,492
2024	10	0.386	0.809		1	15,268,719	5,886,752		$7.08	[illegible]	8024	$0.057	$867,[illegible]20	[illegible]
2025	11	0.350	0.786		1	15,192,375	5,324,835		$7.18	$7.18	8024	$0.058	$875,716	$306,933
2026	12	0.319	0.762		1	15,116,413	4,816,555		$7.25	$7.25	8024	$0.058	$878,910	$280,048
2027	13	0.290	0.737		1	15,040,831	4,356,793		$7.34	$7.34	8024	$0.059	$886,222	$256,707
2028	14	0.263	0.713		1	14,965,627	3,940,917		$7.34	$7.34	8024	$0.059	$881,338	$232,084
2029	15	0.239	0.688		1	14,890,799	3,564,739		$7.67	$7.67	8024	$0.062	$916,076	$219,301
2030	16	0.218	0.663		1	14,816,345	3,224,468		$7.91	$7.91	8024	$0.064	$940,851	$204,757
2031	17	0.198	0.637		1	14,742,263	2,916,678		$8.21	$8.21	8024	$0.066	$970,891	$192,086
2032	18	0.180	0.612		1	14,668,552	2,638,268		$8.43	$8.43	8024	$0.068	$991,701	$178,366
2033	19	0.164	0.587		1	14,595,209	2,386,433		$8.70	$8.70	8024	$0.070	$1,018,388	$166,515
2034	20	0.149	0.563		1	14,522,233	2,158,637		$8.95	$8.95	8024	$0.072	$1,043,264	$155,075
2035	21	0.135	0.543		1	14,449,622	1,952,586		$9.21	$9.21	8024	$0.074	$1,068,202	$144,347
2036	22	0.123	0.523		1	14,377,374	1,766,202		$9.47	$9.47	8024	$0.076	$1,092,030	$134,152
2037	23	0.112	0.504		1	14,305,487	1,597,610		$9.73	$9.73	8024	$0.078	$1,116,581	$124,698
2038	24	0.102	0.485		1	14,233,960	1,445,111		$9.99	$9.99	8024	$0.080	$1,140,697	$115,810
2039	25	0.092	0.467		0	0	0		$10.25	$10.25	8024	$0.082		
2040	26	0.084	0.449		0	0	0		$10.51	$10.51	8024	$0.084		
2041	27	0.076	0.431		0	0	0		$10.78	$10.78	8024	$0.086		
2042	28	0.069	0.414		0	0	0		$11.04	$11.04	8024	$0.089		
2043	29	0.063	0.397		0	0	0		$11.31	$11.31	8024	$0.091		
2044	30	0.057												
Total							154,486,171							$7,266,989

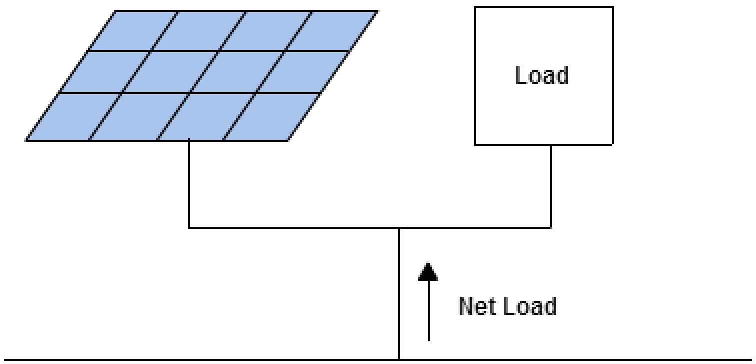
EXAMPLE

Agenda

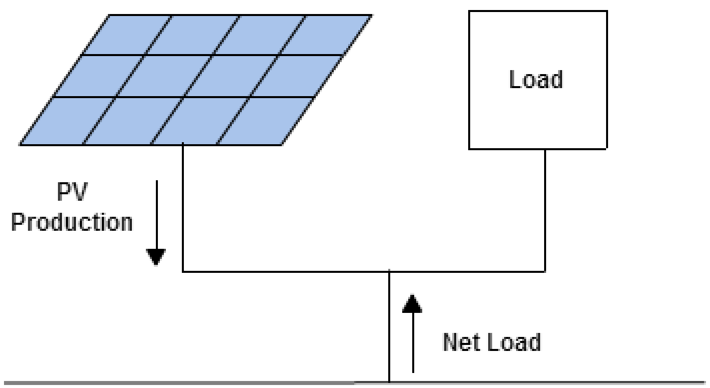
- Background
- **Framework**
- VOS Components
- Fleet Production Shape
- Loss Savings
- Economic Methods

Billing Quantities

NET LOAD



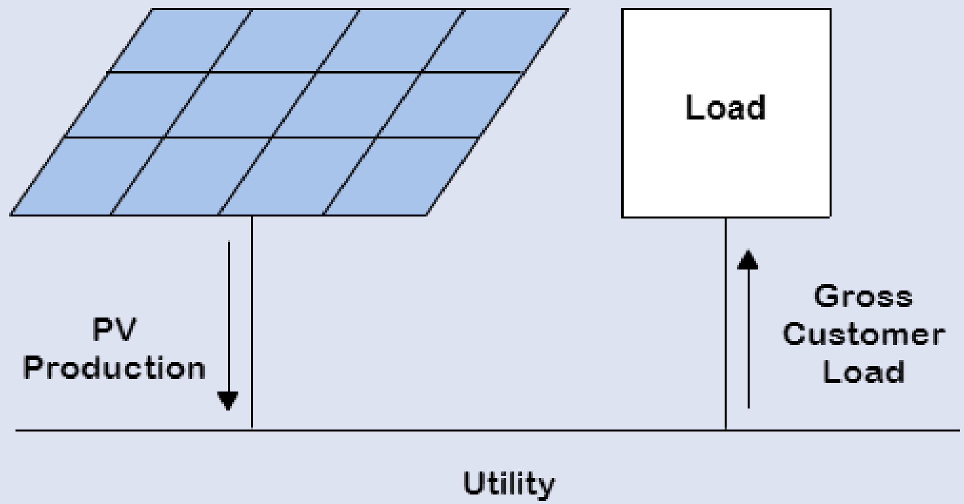
PV AND NET LOAD



VOS FRAMEWORK:

Separates charges and credits

- VOS Credit applies to PV production
- Consumption charges apply to gross Customer Load



Charges and Credits

- “credits the customer for all electricity generated by the solar photovoltaic device"
- “charges the customer for all electricity consumed by the customer at the applicable rate schedule for sales to that class of customer”
- Conclusions:
  - The VOS credit will be associated with all production (not with “export” energy)
  - Rates for consumption will be based on gross consumption (not “net” consumption)
  - Rates and standby charges for consumption are not dependent upon whether the customer has PV or not. Rates will allow utility to collect cost of serving customers, independent of PV production. Future rates can be designed to allow the utilities to recover the cost of VOS credits from all customers.

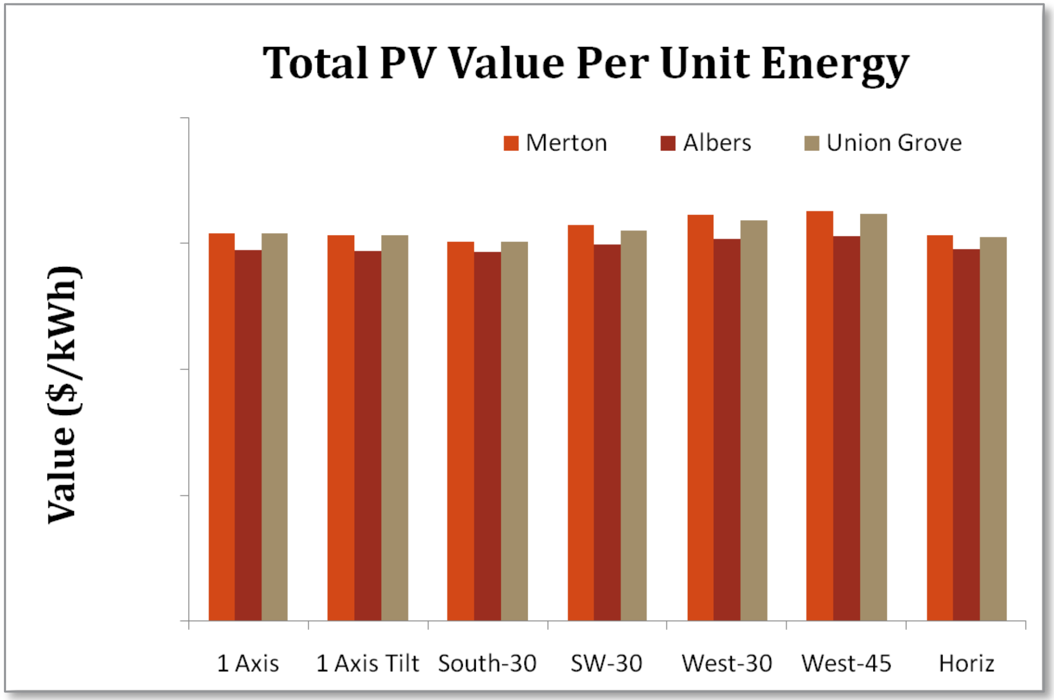
No Cross Subsidization

No cross subsidization between solar and non-solar customers, or between customers of different rate classes:

- All customers pay for consumption according to the applicable rate schedule. Solar customers are treated the same as other customers with respect to consumption.
- VOS components that represent utility savings:
  - The overall cost of service is not affected (e.g., the savings gained from capacity costs is directly offset by increased cost of VOS credits).
  - Since there is no increase in cost, there would be no impact on rates.
- VOS components that represent societal benefits:
  - All customers (solar and non-solar) pay the same rates. If a societal benefit is included in the VOS rate, this represents a new utility expense that is recoverable through rates.
  - This expense is recovered using the same ratemaking procedure as other utility expenses.
  - All customers (solar and non-solar) pay for this new expense through consumption.

VOS Depends on Location and Orientation

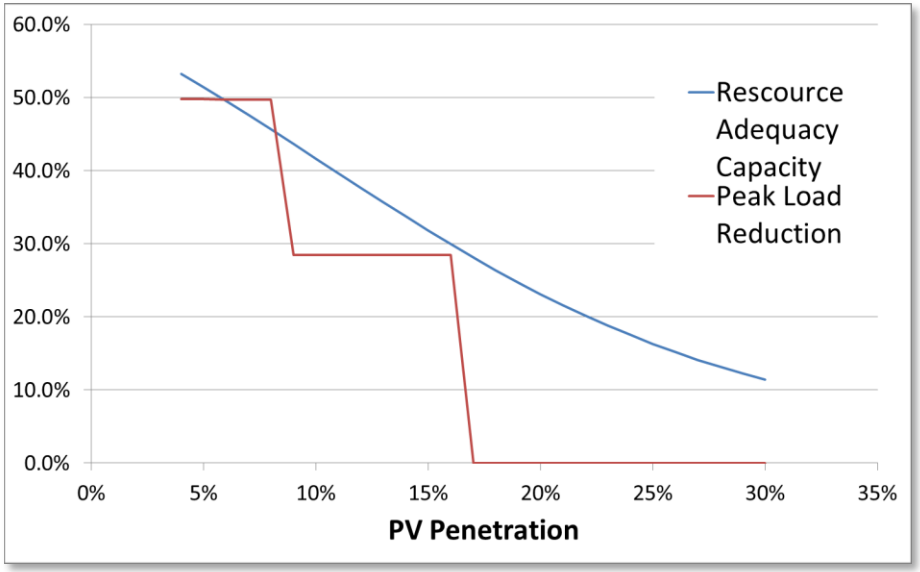
- VOS could be differentiated by location (PV resource, distribution growth/costs, LMP node) and orientation
- Utility service territory provides some inherent geographic differentiation
- These add substantial complexity
- Value should be calculated for utility "fleet," incorporating the diversity of orientations and the overall geographic diversity



Recommendation:
Calculate separate VOS for each utility for each year, applicable to most locations and all orientations

VOS Depends on Penetration Level

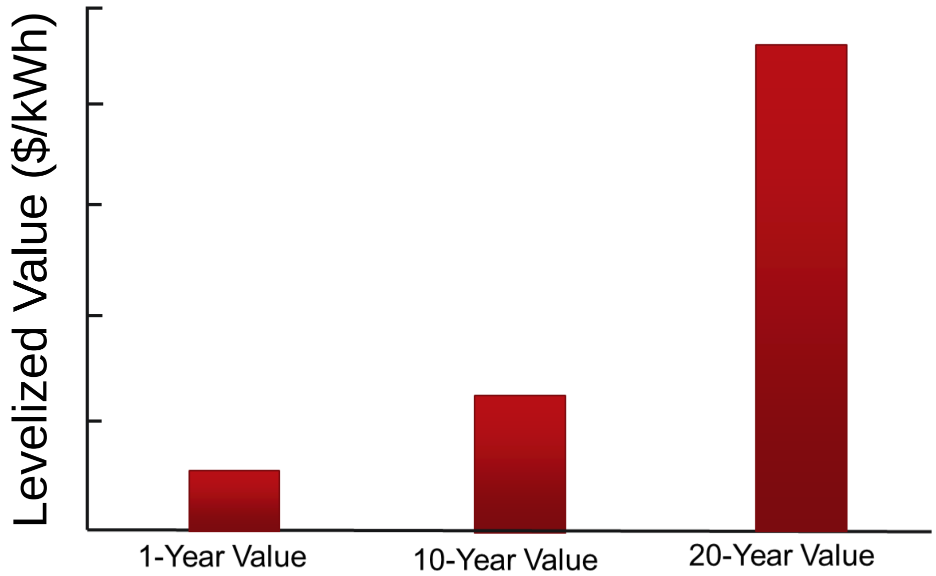
- Much higher PV penetration results in less effective capacity.
- This results in lower capacity value for generation, transmission, and distribution.
- To include this upfront:
  - Requires forecast of PV penetration levels
  - Penalizes early adopters for solar capacity brought by late adopters.
- Existing penetration is incorporated in hourly loads
- Future year VOS calculation will incorporate actual penetration for that year.



Recommendation:
Assume current penetration for full contract term; adjust each year when VOS is recalculated.
Early adopters will have VOS calculated with higher capacity value

VOS Depends on Term

- Levelized value incorporates value over a fixed study period
- Most value studies set study period equal to useful PV service life (20 to 30 years, degradation included)
- Levelized value converts present value to fixed contract term (20 years minimum as required by legislation).
- Assume that valuation period is the same as contract period to avoid confusion.
- If PV life extends beyond contract term, future credit can be determined then.



Recommendation: Assume

- 25 year life,
- 25 year value,
- 25 year levelization

VOS Does Not Necessarily Depend on Rate Class

- Framework
  - A kWh produced and delivered to the grid by PV has a certain value, whether a utility savings or a benefit to society.
  - Whether the kWh was produced by a residential customer, a commercial customer, an industrial customer, and agricultural customer, etc., it provides the same utility savings or societal benefit.
  - Systems that are larger, better maintained, better designed with fewer losses, etc., will deliver more energy than others, and consequently more total benefits.
- Conclusions
  - The credit should be “pay for performance,” computed on a per-energy basis (rather than a per-kW or similar basis).
  - If the system is dirty, off-line, poorly designed, or otherwise not performing well, this will be reflected in the credit amount.
  - The credit should be the same for all kWh as delivered to the grid.

Summary: VOS Proposed Framework

- VOS will be the same for all participants
  - at a given utility
  - who enter contract in a given year
  - regardless of orientation
- VOS will represent current penetration level, unchanged for all years of study period. Future VOS re-calculations will use penetration level in that year. Other changes to methodology are possible in future years.
- VOS credit will be fixed for all years of a fixed contract term.

Recommendation: the VOS Credit to be a 25 year levelized amount ($ per kWh) for all PV production.

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- Background
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- **VOS Components**
- Fleet Production Shape
- Loss Savings
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VOS Candidate Components (1 of 2)

Value Component	Basis	Legislative Guidance
Avoided Fuel Cost	MISO energy market costs (portion attributed to fuel).	Required (energy)
Avoided Plant O&M Cost	MISO energy market costs (portion attributed to O&M).	Required (energy)
Avoided Generation Capacity Cost	Capital cost of generation to meet peak load.	Required (capacity)
Avoided Reserve Capacity Cost	Capital cost of generation to meet planning margins and ensure reliability.	Required (capacity)
Avoided Transmission Capacity Cost	Capital cost of transmission.	Required (transmission capacity)
Avoided Distribution Capacity Cost	Capital cost of distribution.	Required (delivery)
Avoided Environmental Cost	Cost to meet utility RPS obligations.	Required (environmental)
Fuel Price Guarantee	Cost to eliminate fuel price uncertainty (natural gas, etc.).	

VOS Candidate Components (2 of 2)

Value Component	Basis	Legislative Guidance
Credit for local mfg/assembly	Local tax revenue tied to net solar jobs	Optional (identified in legislation)
Credit for high value distribution locations		Optional (identified in legislation)

Other Possible Components May Include

Value Component	Basis	Legislative Guidance
Voltage Control	Cost to regulate distribution (future inverter designs)	
Market Price Reduction	Cost of wholesale power reduced according to reduction in demand.	
Disaster recovery	Cost to restore local economy (requires energy storage and islanding inverters)	

T&D Losses

- Transmission and distribution line losses **must** be accounted for in the VOS Credit. Loss savings will be included in the calculation of each component, but they are not considered separate components.

> Example: if avoided fuel costs are calculated as \$0.05 per kWh and loss savings between the customer and the LMP node are 10% of PV output, then the fuel savings is calculated as \$0.05 x 1.1 = \$0.055 per kWh.

Which Benefits Should be Included?

- Decision is to be made by Department of Commerce with inputs from stakeholders and Clean Power Research

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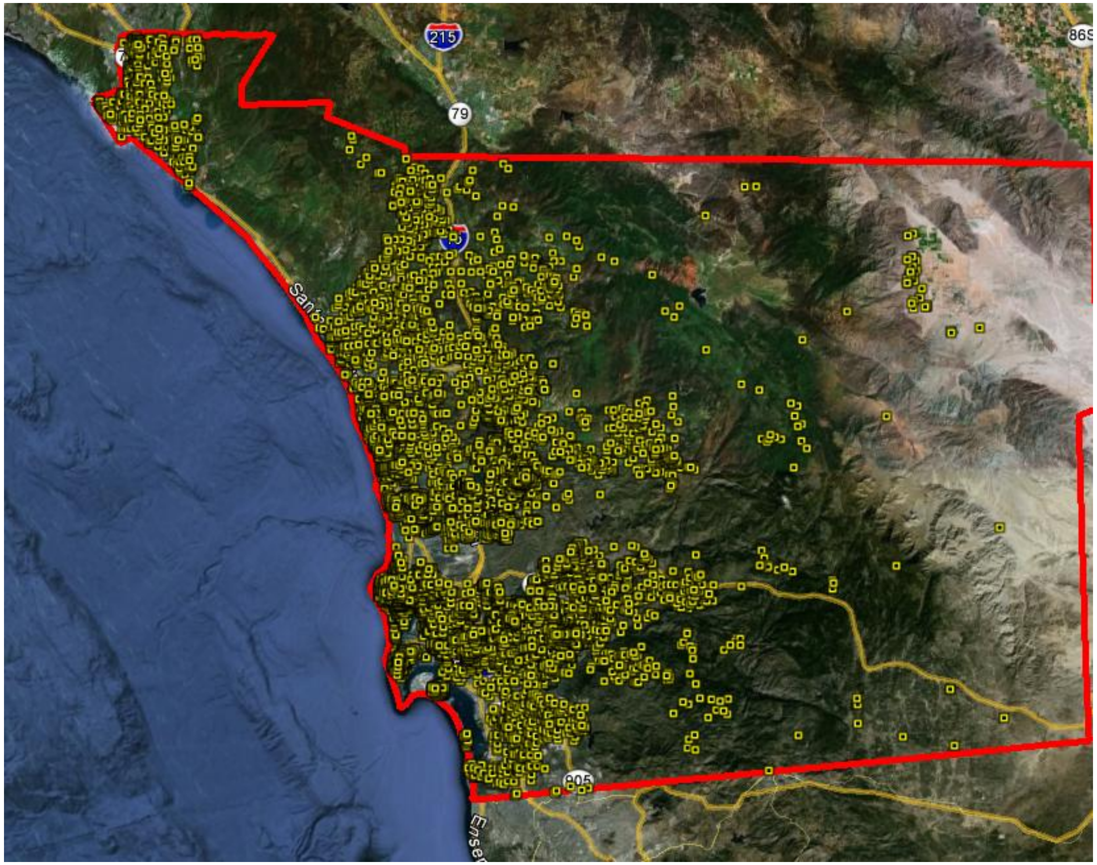
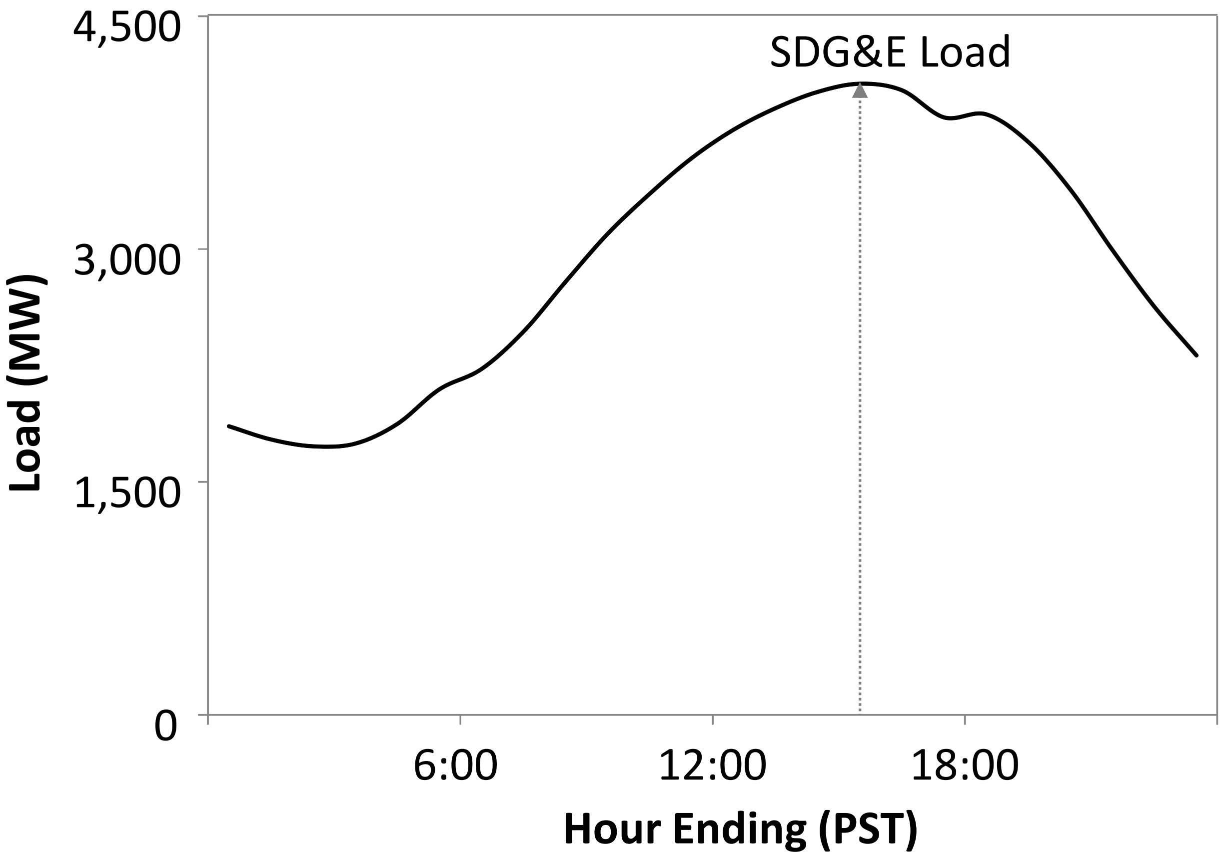
A Lesson from San Diego on the Peak Load Day (9/14/2012)

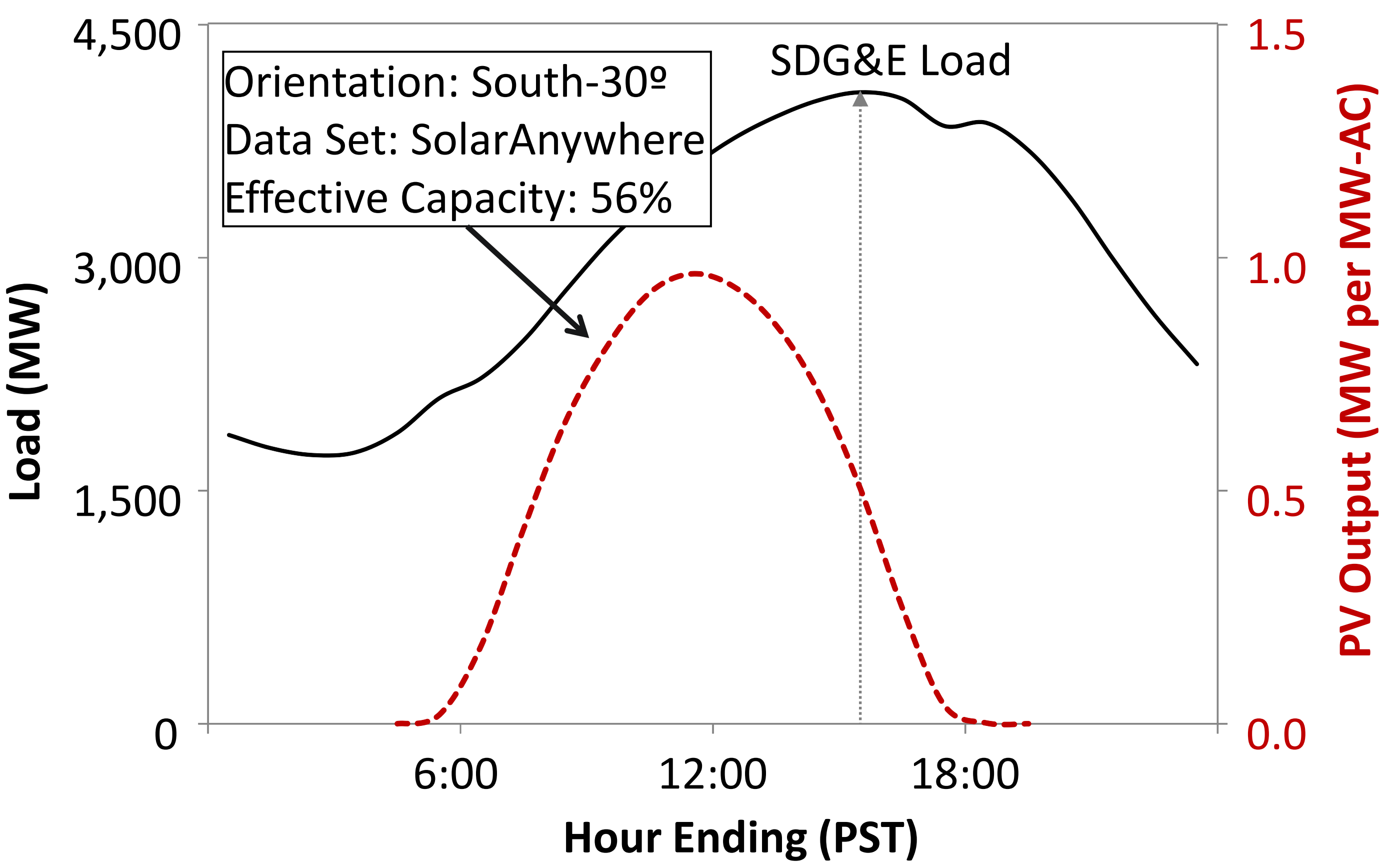


SDG&E Fleet (2012)
16,384 Behind the meter PV systems
117 MW-AC Fleet Capacity

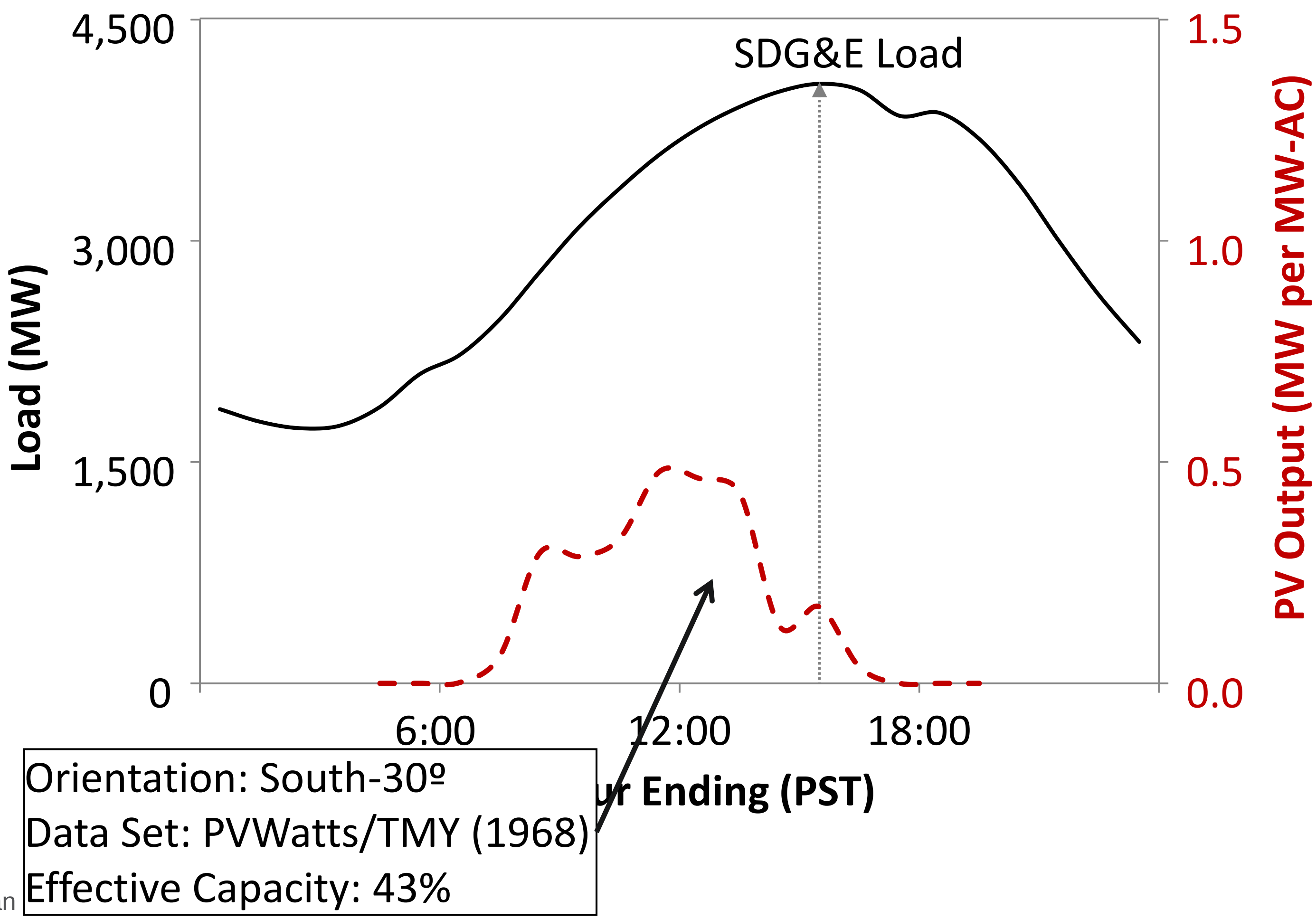
A Lesson from San Diego on the Peak Load Day (9/14/2012)



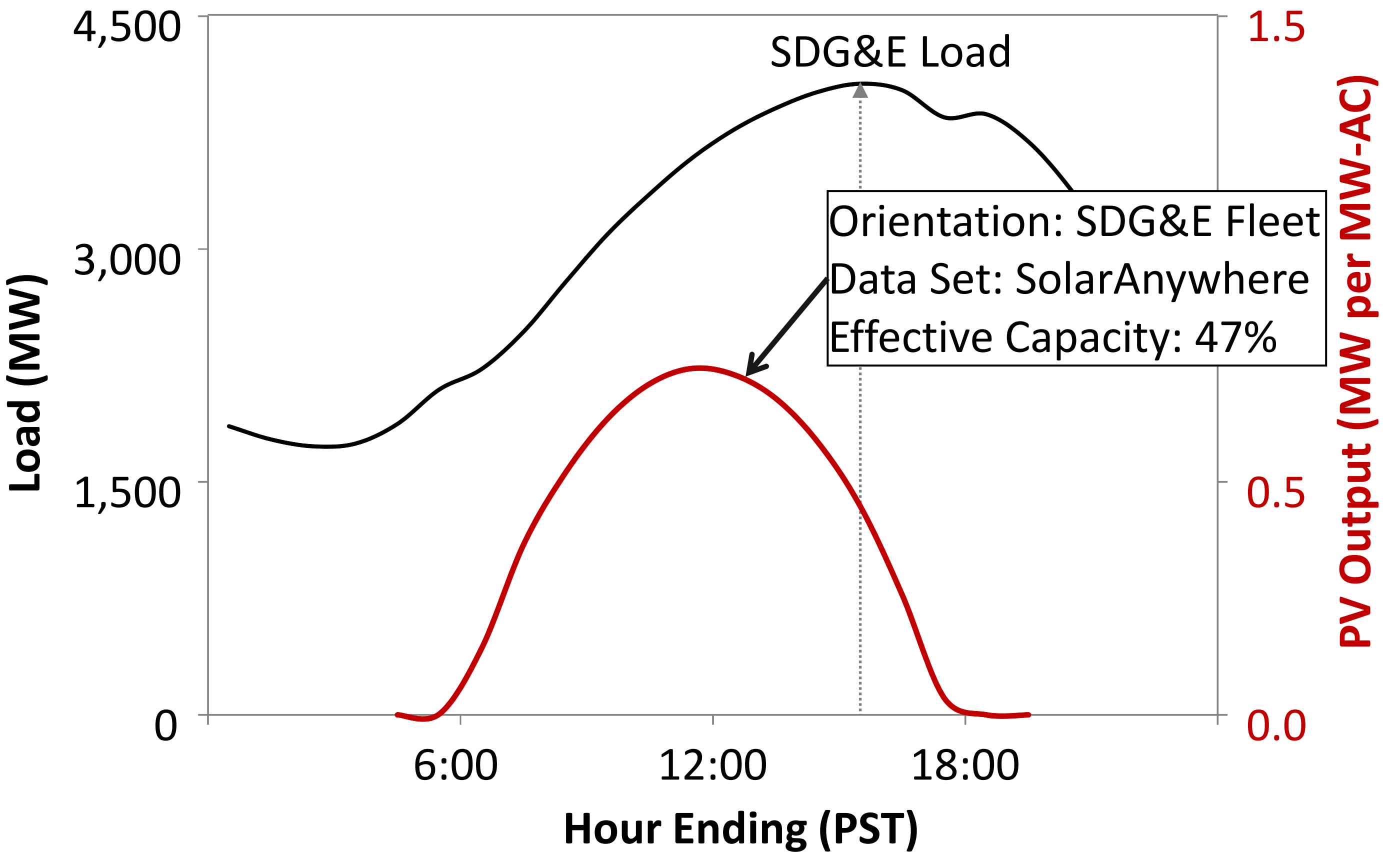
Time-Synchronized Solar Resource Data & ***Assumed*** PV Fleet Specifications



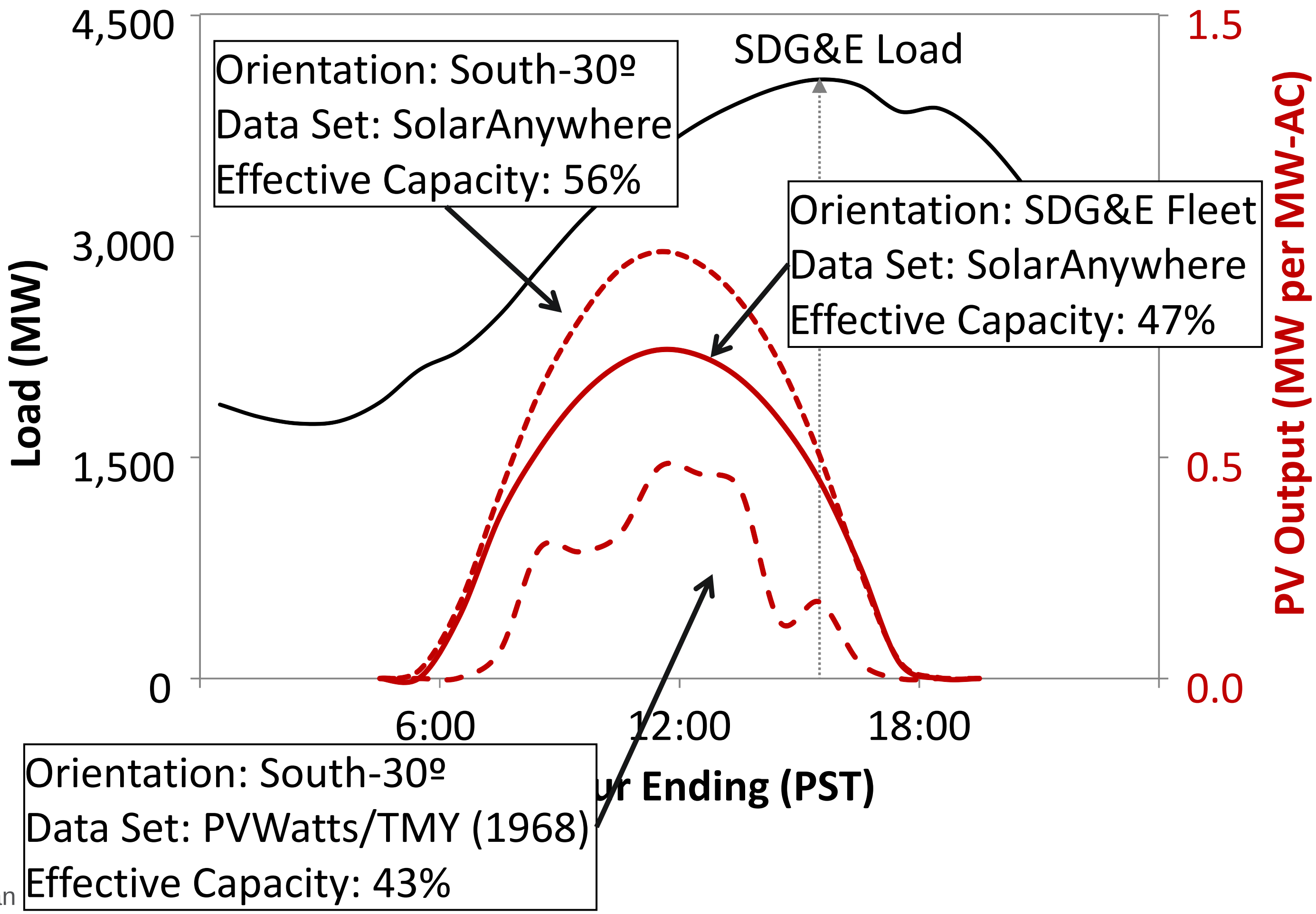
Non-Time-Synchronized Solar Resource Data & ***Assumed*** PV Fleet Specifications



Time-Synchronized Solar Resource Data Actual PV Fleet Specifications



Conclusion: Use **Time-Correlated** Solar Resource Data and **Actual** PV Fleet Specifications



Obtaining Fleet Production Shape

Details will be specified in methodology

Method	Procedure	Notes
OPTION 1 Fleet Metered Sub-sample	• Obtain hourly measured data from sample of PV systems in territory • All systems in place over load study year • Aggregate hourly sample output • Divide hourly results by sample capacity	• Unclear what minimum sample size should be • Must be random sample covering diversity of geographic locations and orientations
OPTION 2 Full Fleet Model	• Obtain system specifications (locations, ratings, orientation, etc.) • Model systems using satellite-based resource data and temperature • Divide hourly results by fleet capacity	• Same specifications can be used for utility load forecasting

Recommendation: Use Option 2

PV Capacity Rating Methods

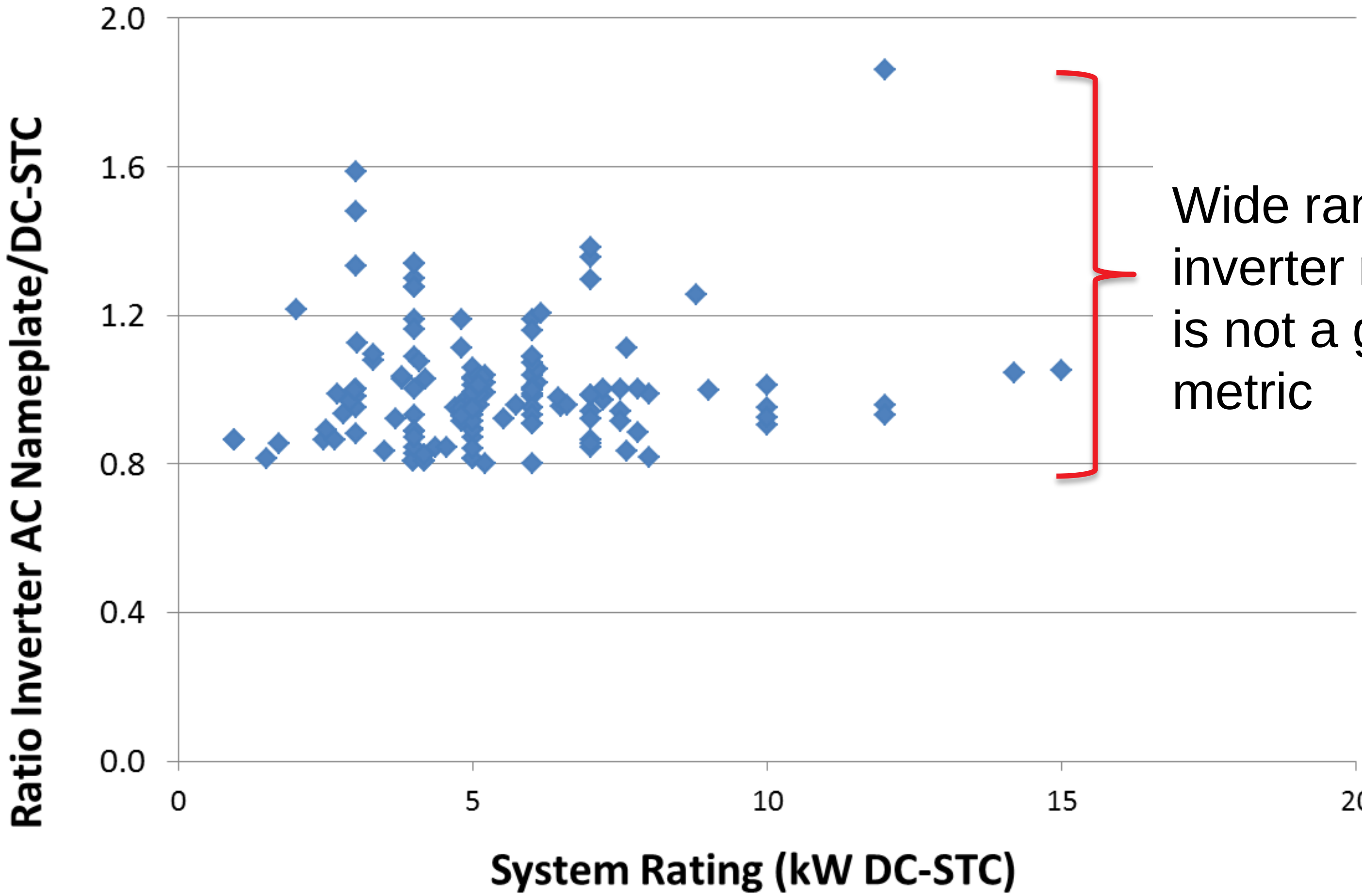
- Multiple rating systems are in use by utility solar programs
  - DC rating at Standard Test Conditions (STC)
  - DC rating at PVUSA Test Conditions (PTC)
  - AC rating w/o Losses (= DC_{ptc} X Inverter Efficiency)
  - AC rating with Losses (= DC_{ptc} X Inverter Efficiency X SystemLossFactor)
  - AC rating based on Inverter Nameplate
- Rating system is arbitrary, but must be used consistently

Example: Effective capacity is 50% of rating. For a 100 kW DC-STC system, this could mean:

- 100 kW x 50% = 50 kW
- (100 kW x 90% x 95% x 85%) x 50% = 36 kW

A 39% discrepancy!

Inverter Nameplate Ratings are Inconsistent



Wide range – inverter nameplate is not a good rating metric

VOS Rating Convention

Recommendation: Use kW-AC

kW-AC = DC-STC x Module Derate x Inverter Efficiency x Loss Factor

Example:

10 kW DC-STC

X 90% module derate factor

X 95% inverter load-weighted efficiency

X 85% other loss factor

7.27 kW-AC

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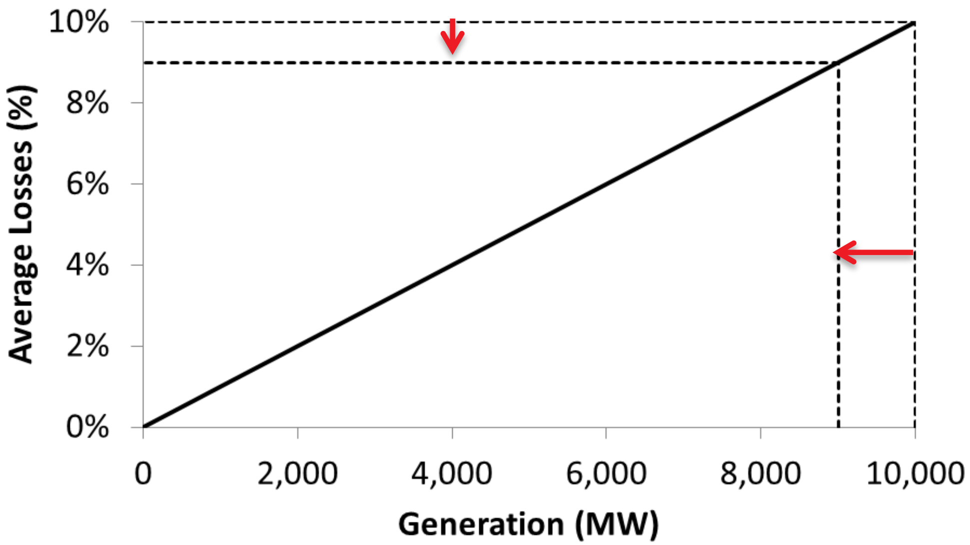
Generation Relates Linearly to Avg. Losses

Example of marginal loss savings calculation for a given hour



	Without PV	With PV	Change
Generation	10,000 MW	9,000 MW	1,000 MW
Avg. Losses	**10%**	9%	
Losses	1,000 MW	810 MW	190 MW
Loss Savings			**19%**

You can't just add 10% to PV production!

Loss Savings Methodology

- Methodology will require these inputs:
  - Peak transmission loss (%)
  - Average transmission loss (%)
  - Peak distribution loss (%)
  - Average distribution loss (%)
  - Hourly load for analysis year
  - Hourly fleet shape for analysis year
- Methodology will deliver four loss savings results:
  - Energy loss savings (%) – distribution only
  - Energy loss savings (%) – combined T&D
  - Generation capacity loss savings (%)
  - Distribution capacity loss savings (%)

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Economic Methods

- The VOS methodology document will document exactly how the economic value of each component is to be calculated.
- The methodology will be described in sufficient detail so that any stakeholder will derive the same value given the same input dataset.

Example: Generation Capacity

Methodology will show how to escalate future cost, the formula for amortizing cost over life of plant, the calculation of present worth of overlapping PV life, the treatment of PV capacity degradation, the discounting of future value, the application of effective PV capacity, and the formula for levelization.

Energy-Related VOS Components

- Definition
  - Benefit from distributed PV generation’s offset of wholesale energy purchases
  - Includes fuel and variable O&M
- Methodology
  - Equals PV output plus loss savings times marginal cost
  - Marginal energy costs are based on fuel and O&M costs of generator operating on the margin (CCGT)

Generation Capacity-Related Components

- Definition
  - Benefit from added capacity provided to the generation system by distributed PV
  - Applies to:
    - Gen capacity required to meet peak load,
    - Gen reserve capacity,
    - Transmission capacity
    - Fixed O&M
- Methodology
  - Equals cost per kW times effective load carrying capability (ELCC)
  - Generation capacity cost is based on capital cost of CCGT
  - Capacity value begins in year zero

Fuel Price Guarantee

- Definition
  - Benefit that distributed PV generation has no fuel price uncertainty
- Methodology
  - Calculated by determining how much it would cost to minimize the fuel price uncertainty associated with natural gas generation

Distribution Capacity Value

- Definition
  - Benefit that distributed PV generation provides in reducing the burden on the T&D system and thus delaying the need for capital investments in the T&D system
- Methodology
  - Equals the expected long-term capacity-related upgrade cost, divided by load growth, times financial term, times the peak load reduction factor

Environmental Value

- Definition
  - Benefit that the environmental footprint of PV is considerably smaller than that of fossil-based generation
- Methodology
  - Options:
    - PV output times MN externalities values (societal value)
    - PV output times REC price (societal value)
    - PV output times solar “premium” (cost of solar PPA over conventional PPA)
    - PV output times cost of renewable PPA times RPS percentage (utility savings)

Summary: VOS Calculation

	Economic Value ($/kWh)	X	Load Match (No Losses) (%)	X	Distributed Loss Savings (%)	=	Distributed PV Value ($/kWh)
Component 1	E1		M1		S1		D1
Component 2	E2		M2		S2		D2
Component 3	E3		M3		S3		D3
…							
							D4
Component N	EN		MN		SN		DN
							Value of Solar

The VOS methodology will include

- methodology to determine hourly PV fleet production shape
- methodology to perform an economic analysis
- methodology for load match analysis (hourly PV/load correlation)
- methodology for marginal loss savings analysis